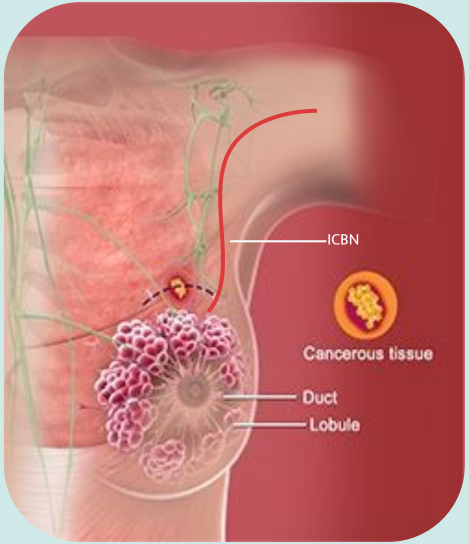
NeuroGuard

Cutting Edge Precision without Cutting Nerves

Meet Leila

36 y/o F hx of breast cancer suffering from post surgical pain



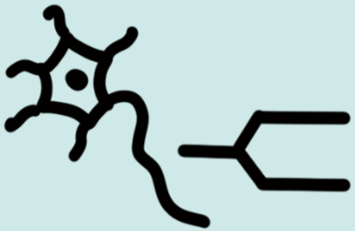
Intercostobrachial Nerve (ICBN)

40-60% [1]

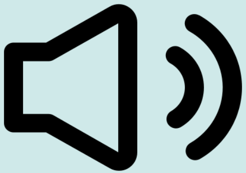
Nerve Injury rate with mastectomy

Over 100,000/year in US[2]

Design Constraints



Contactless Nerve Detection



Real-Time Feedback

Surgical Functionality

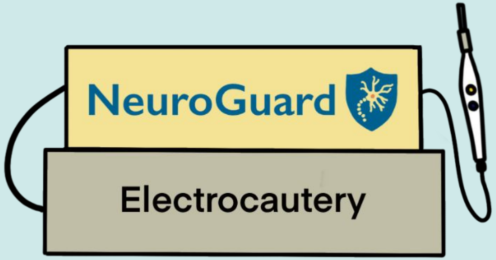
Patient Injury

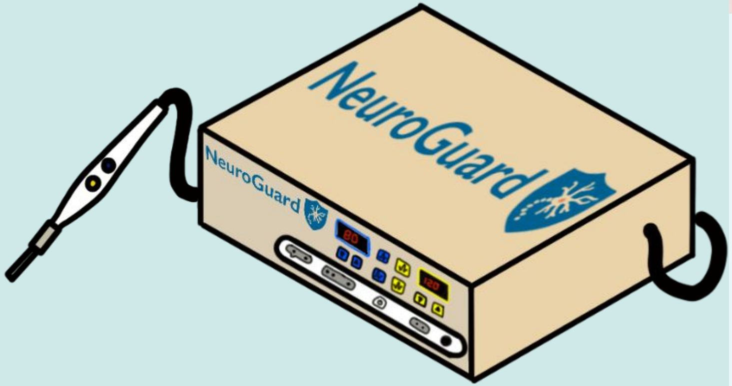
Cost

Integration

NeuroGuard

- ✓ Detects anatomically-important nerves beyond 1 cm distance during electrocautery
- ✓ Provides real-time feedback
- ✓ Integrates with existing tools
- ✓ Nerve-specific (based on modeling)



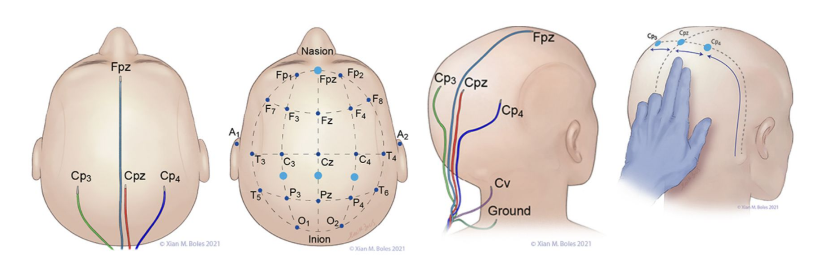


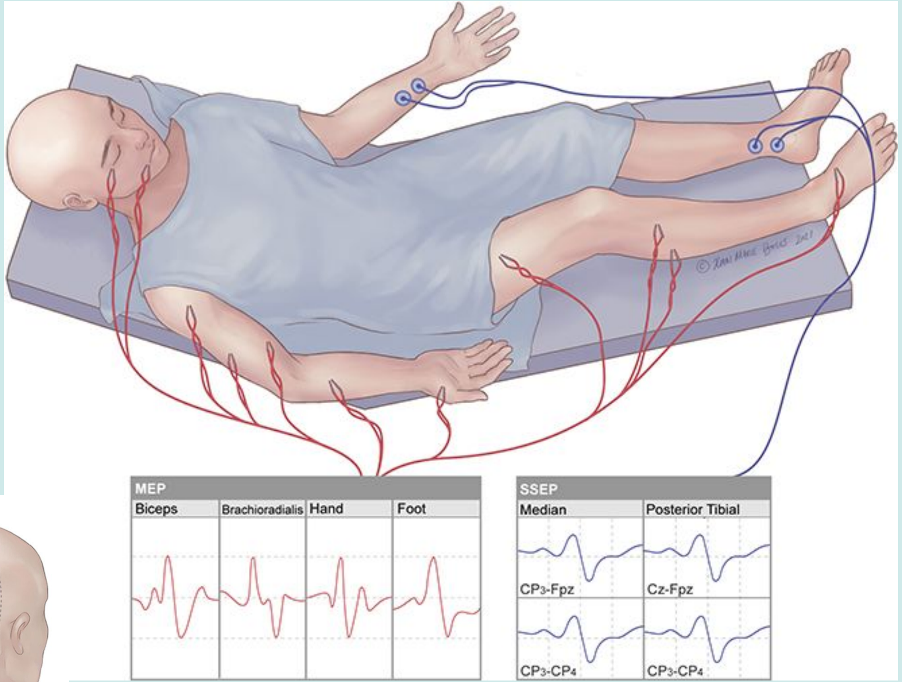
SSEPs

Somatosensory evoked potentials:

- Intraoperative measurement of peripheral nerve activation through stimulation

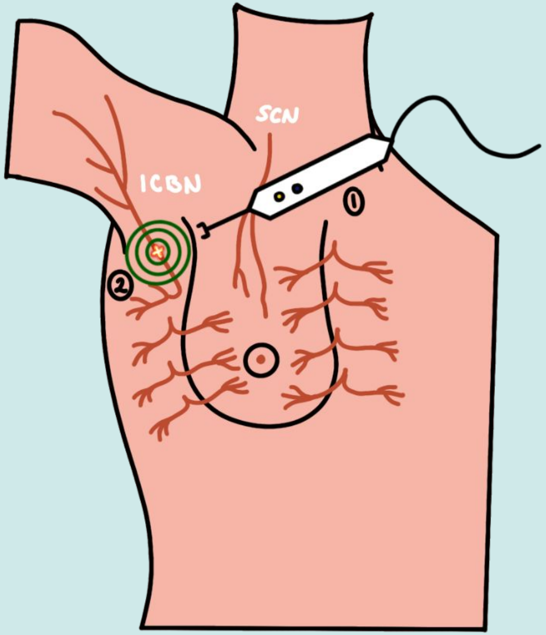
Head SSEPs setup

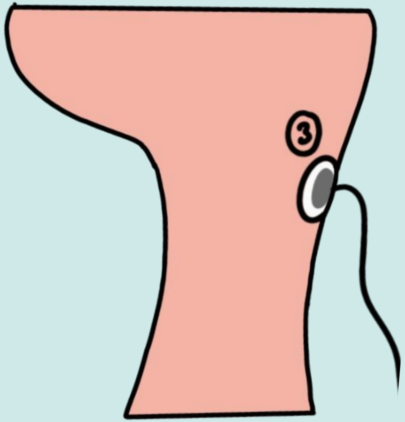




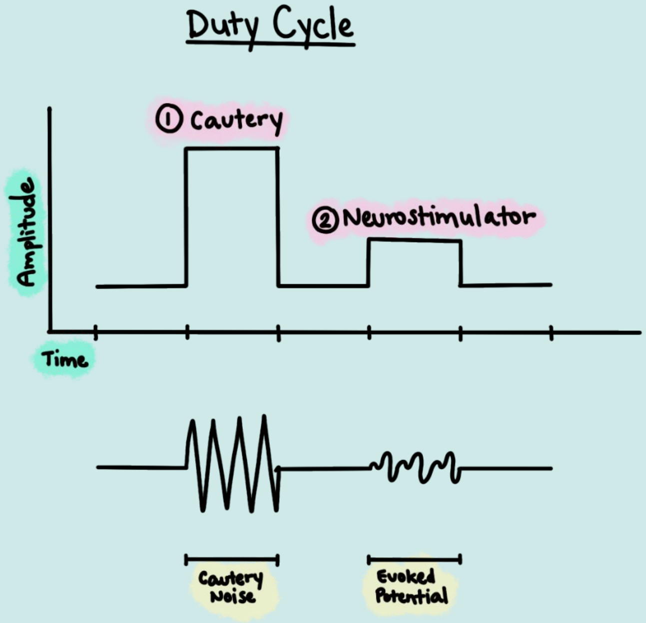
The Bi Lab, Brigham and Women's Hospital

Neuroguard Components





3. Sensory nerve detection via distal electrode

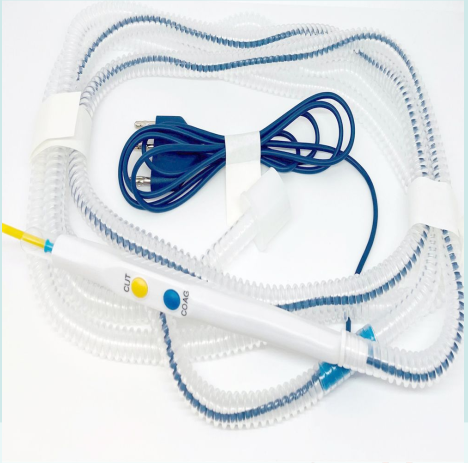


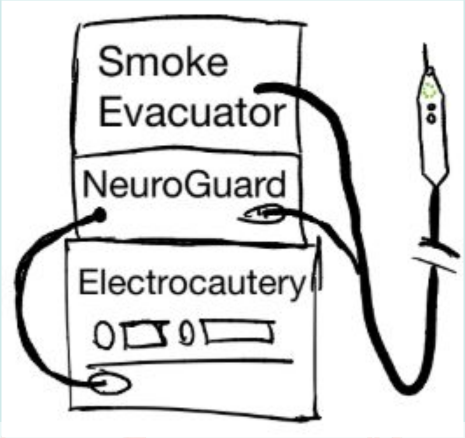
1. Stimulation during 100ms duty cycle
2. Recording response

4. SSEPs → real-time feedback

Integration with existing tools

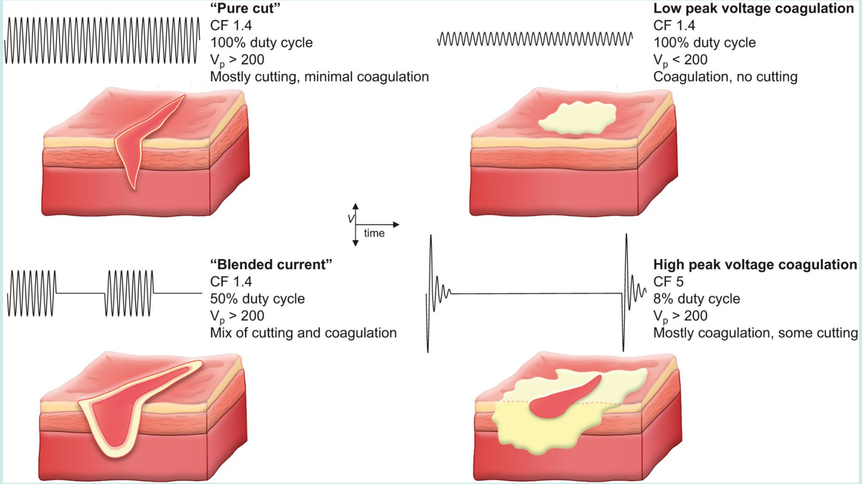
- We envision our device as an add on to electrocautery generator
  - Lower costs, more accessible, small learning curve
  - NeuroGuard probes which are compatible with Bovie and smoke evac systems





Duty cycle modification ideas

Electrocautery concepts



OUTPUT CHARACTERISTICS

Maximum Output for Monopolar and Bipolar Modes

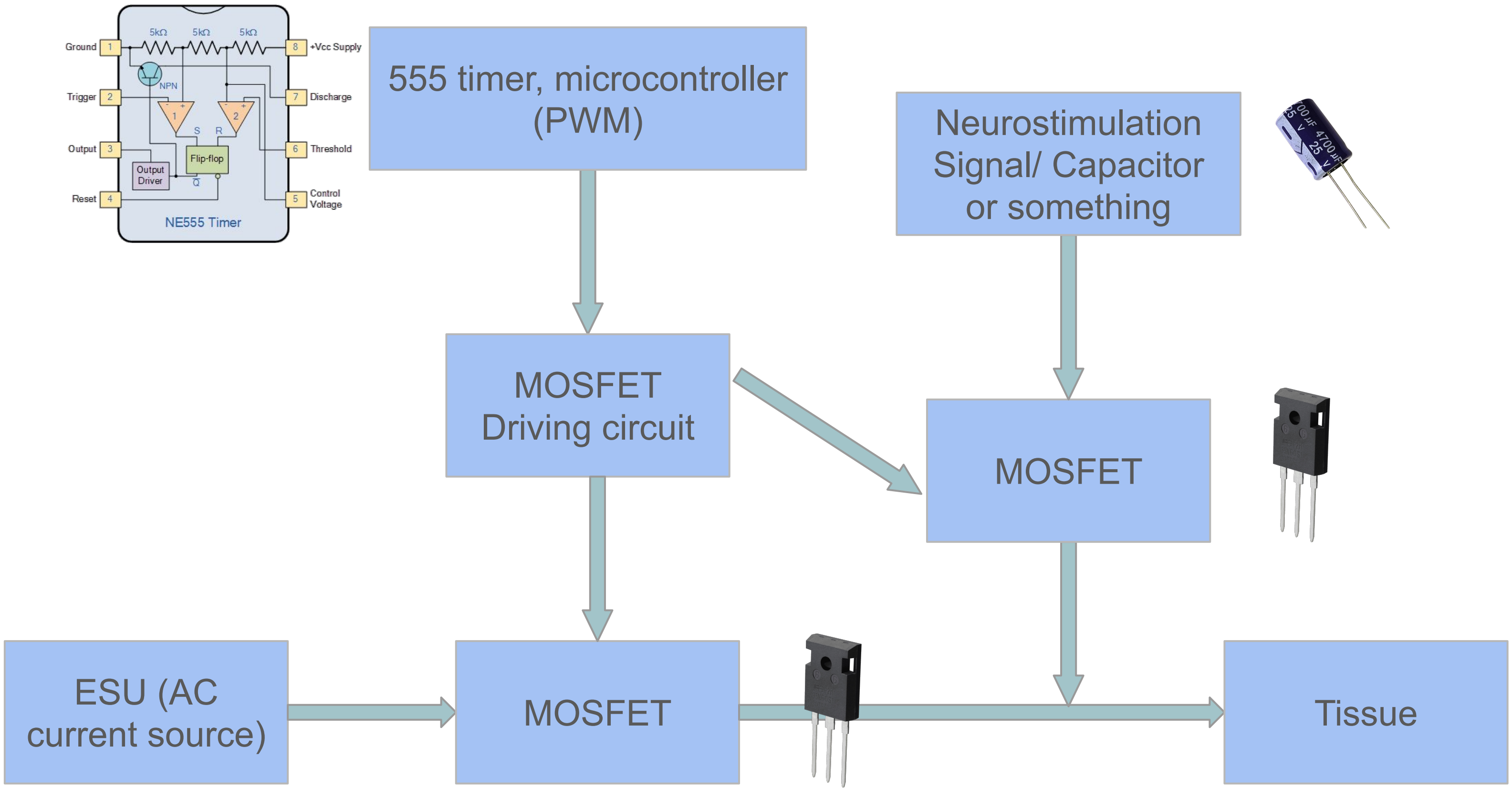
Power readouts agree with actual power into rated load to within 20% or 5 watts, whichever is greater.

Mode	Output Power	Output Frequency	Repetition Rate	Open Circuit Vpeak max	Crest Factor* (Rated Load)
Cut	120 W @ 500 Ω	357 kHz ± 50 kHz	N / A	1250V	2.9 ± 20%
Blend	90 W @ 800 Ω	357 kHz ± 50 kHz	30 kHz ± 5 kHz	1850V	3.3 ± 20%
Coagulation	80 W @ 1000 Ω	475 kHz ± 19 kHz	57 kHz ± 5 kHz	3300V	5.5 ± 20%
Fulguration	40 W @ 1000 Ω	410 kHz ± 50 kHz	25 kHz ± 5 kHz	3900V	7.7 ± 20%
Bipolar	30 W @ 200 Ω	520 kHz (-14 kHz, +29 kHz)	32 kHz ± 5 kHz	1200V	6.9 ± 20%

* an indication of a waveform's ability to coagulate bleeders without a cutting effect

From bovie manual

Design concept #2: external power



the Bovie patent (US 9,326,810 B2)

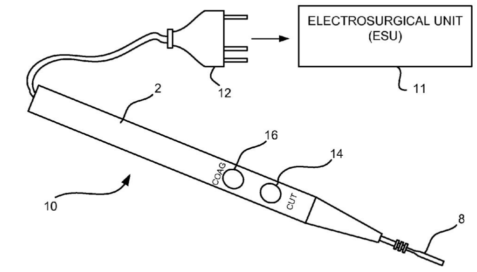


FIG. 1

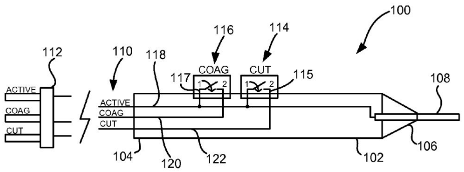


FIG. 2

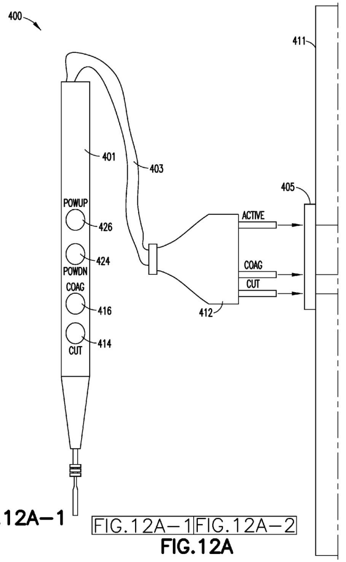
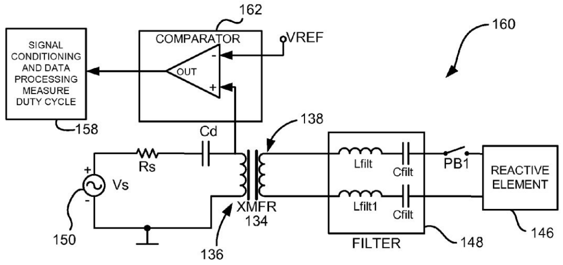


FIG.12A



VOLTAGE/CURRENT SOURCE WITH DUTY CYCLE MEASUREMENT

FIG. 6

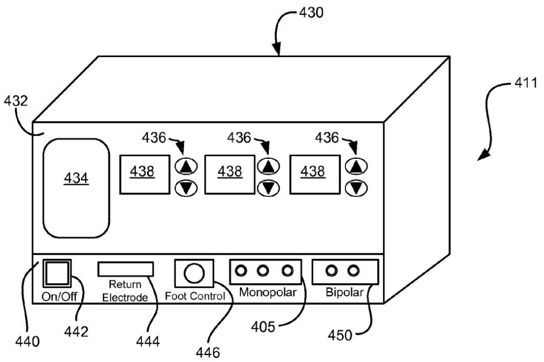


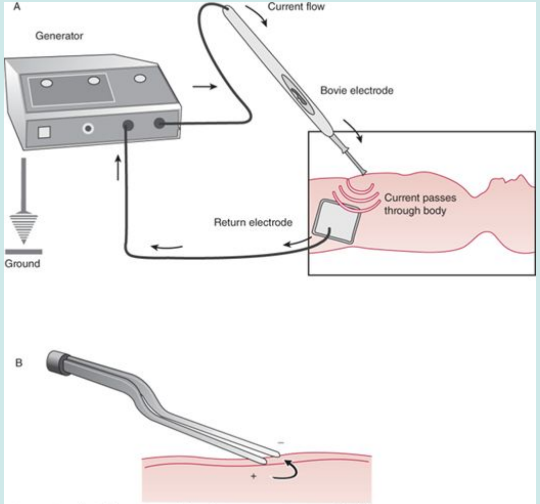
FIG. 12B

Goals/constraints

We would like to modulate the duty cycle generated by standard electrocautery units, to incorporate a stimulatory component that is specifically targeted for nerve activation

- Monopolar setup

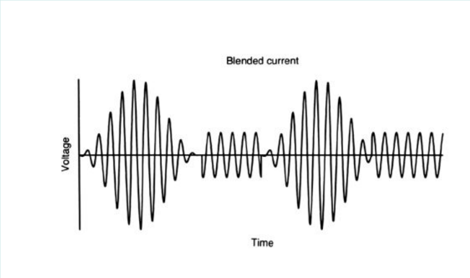
1. Electrocautery duty cycle: 5-50%
2. Electrocautery frequency: 500 kHz - 3 MHz
3. Nerve stimulation frequency: 50 Hz - 1 kHz
    a. Pulse width: 100us - 1ms



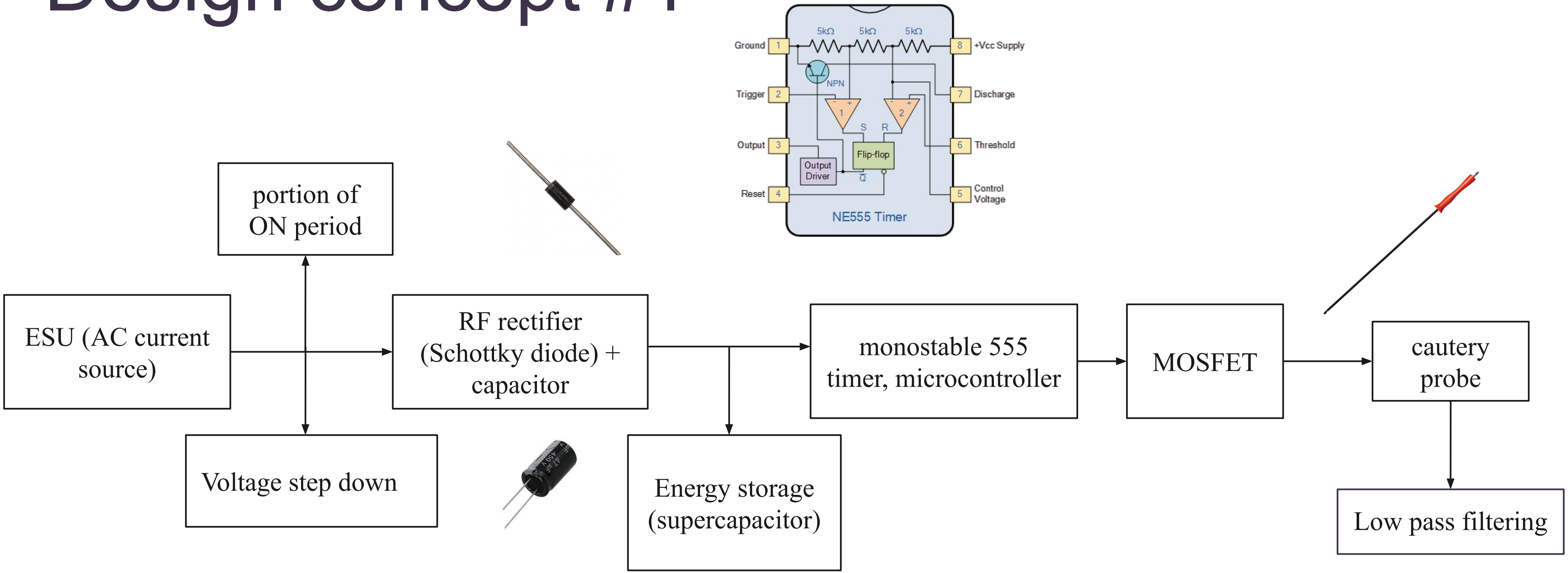
Source: Gerard M. Doherty: Current Diagnosis & Treatment: Surgery, 14th Edition
www.accessmedicine.com

Design ideas

1. Time division multiplexing
    a. Nerve stimulation voltage delivered during OFF periods of duty cycle
    b. Superimpose the neurostimulator frequency during the OFF phase of the electrocautery duty cycle
    c. External device (Arduino microcontroller) could take in signal from electrocautery and time when nerve stimulation occurs (or have it be pre-programmed based on %)
    d. Measure with oscilloscope
2. Low frequency modulation
    a. I.e. blended current
    b. Modulate electrocautery with nerve stimulation frequency
    c. Noise issues → filtering
3. Harmonic Filtering
    a. Separate tip

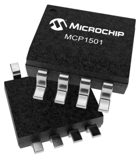


Design concept #1



- Voltage step-down:
- Transformer, DC-DC converter, low-dropout regulator

Design concept #1

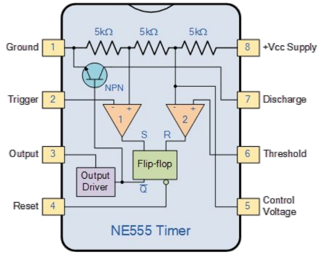


Powering nerve stim with ESU

- Rectifier + filter high frequency: AC → DC current
- Voltage step-down: DC-DC converter, low-dropout regulator
- Energy storage → powers OFF periods of duty cycle (supercapacitor)

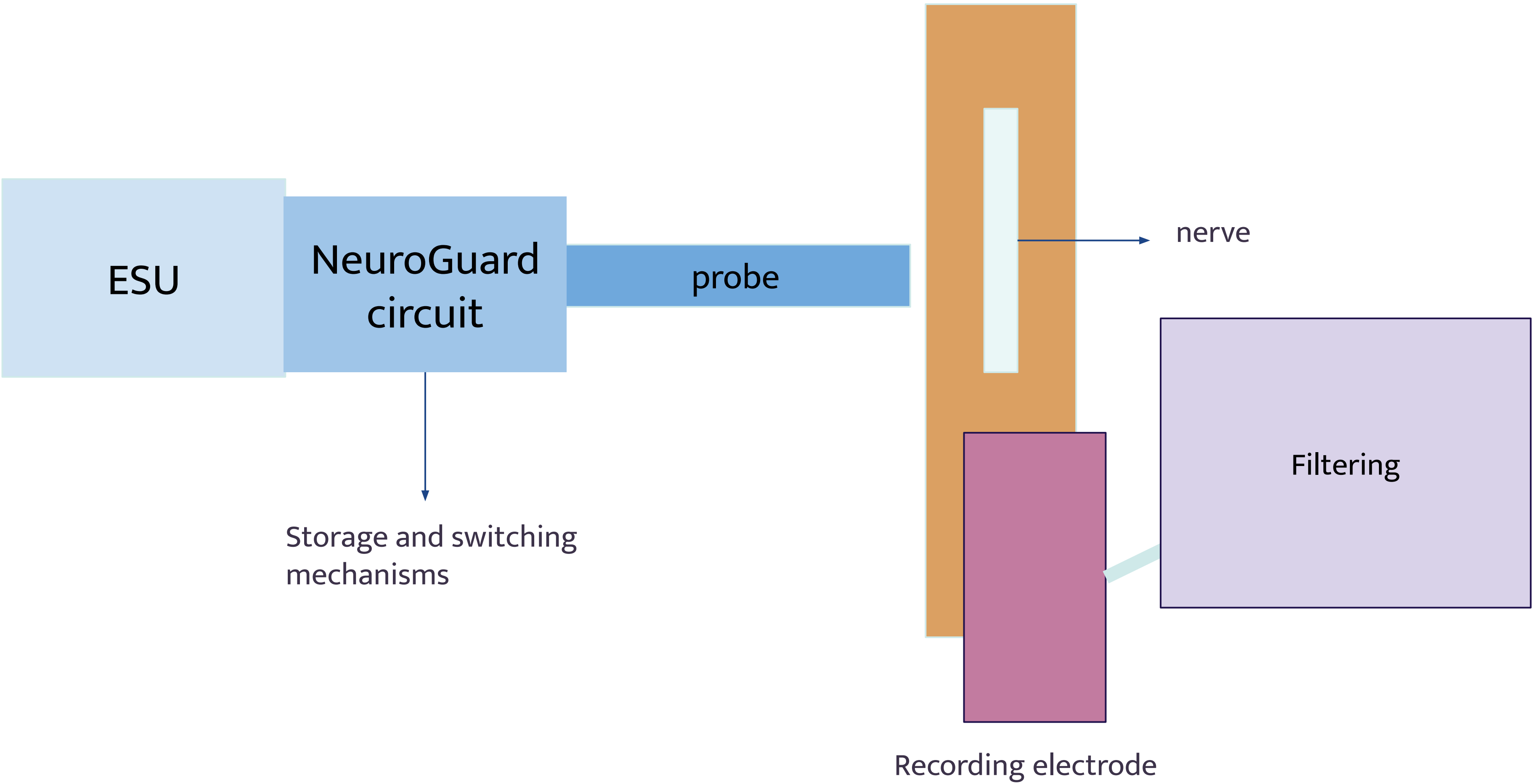
Voltage reference IC (2 V) → Voltage divider (0.2 V)

Low pass filtering



ESU (AC current source) → RF rectifier (Schottky diode) + capacitor → monostable 555 timer, microcontroller

Energy storage


ESU
NeuroGuard circuit
probe
nerve
Storage and switching mechanisms
Filtering
Recording electrode

Design concept #3

555 timer controls when nerve stimulation is delivered